

Applicants: Heung Nam HAN et al.  
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**Amendments to the Drawings:**

Please replace the replacement drawing sheet filed with the Amendment dated June 10, 2005 which contains Figs. 2-4, with the Replacement Sheet containing clearer replacement Figs. 2-4 attached in Exhibit A. The descriptive label "1 mm" also has been omitted from Figs. 2-4, and further descriptive labels "Aluminum" and "Copper" have been omitted from Fig. 4.

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Remarks

Claims 1, and 4-5 are pending and presently being examined.

Section 1 of the Office Action objected to the replacement drawings for Figs. 2-4 as not being clear and required correction.

Applicants hereinabove have amended the drawings to replace Figs. 2-4 to more clearly show the subject matter of the present invention shown in original Figs. 2-4 as required in the Office Action. For clarity, replacement Figs. 2-4 omit the descriptive labels "1 mm", and replacement Fig. 4 further omits the descriptive labels "Aluminum" and "Copper". Support for these amendments can be found, inter alia, in original Figs. 2-4 and on page 5 in lines 5-14 of the subject specification. Applicants respectfully submit that no new matter has been introduced by the drawing amendments.

In view of the remarks above, the amendments to Figs. 2-4, and the Replacement Sheet in Exhibit A, applicants respectfully request that the objections to Figs. 2-4 be reconsidered and withdrawn.

Sections 2 and 3 of the Office Action rejected claims 1 and 4 under 35 U.S.C. §102(e) as being anticipated by Japan Patent Publication No. 2003-181655 A to Tanaka et al. ("Tanaka publication"). More specifically, the Office Action stated that the Tanaka publication teaches each element of claims 1 and 4.

Applicants respectfully submit that the present invention as recited in claim 1 produces "intense plastic deformation" only "at surfaces" of two (2) workpieces by using a "no-pin probe", thereby welding two (2) workpieces together without leaving a 'keyhole'. The width of the plasticised region of the workpieces is substantially equal to the diameter of the lower end of the no-pin probe 'at the upper surfaces' of the work pieces 'just under the probe', see page 6 in lines 6-11 of the present specification.

In contrast, the probe of the Tanaka publication which is always angled relative to the upper surfaces, see Figs. 5 and 7 of the Tanaka publication, must act like a pin probe in penetrating the upper surface of at least one of the workpieces. For example, the following mathematical formula from claim 1 of the Tanaka publication ("Tanaka formula") must be satisfied when performing friction stir welding in accordance with the Tanaka publication for two (2) workpieces having different heights:

$$(t_1+t_2)/2 - r \cdot \sin \theta < 1, \quad (1)$$

where  $r \geq 15$ , and  $\theta \leq 5$ .

From the Tanaka formula, when the heights of two workpieces are different from each other, for example, the thickness of one workpiece is 2.0 mm, the other workpiece thickness is 2.5 mm, and the inclination angle of the cylindrical probe is 5° off from the perpendicular position relative to workpieces, the radius of the probe must be 14.3 mm or more. Therefore, for butt seam welding with two workpieces in this example, at least the edge of the probe will inevitably penetrate into the thinner workpiece, in this example, the workpiece having 2.0 mm thickness. Thus, according to the Tanaka patent, the probe is inserted into a workpiece to the extent of depth required to match the difference of thicknesses between two workpieces, that is, with the value of  $r \cdot \sin \theta$ .

In addition, the Tanaka formula can be rewritten to cover the situation of two workpieces of the same thickness ( $t_1=t_2$ ). This formula ("Rewritten formula") is:

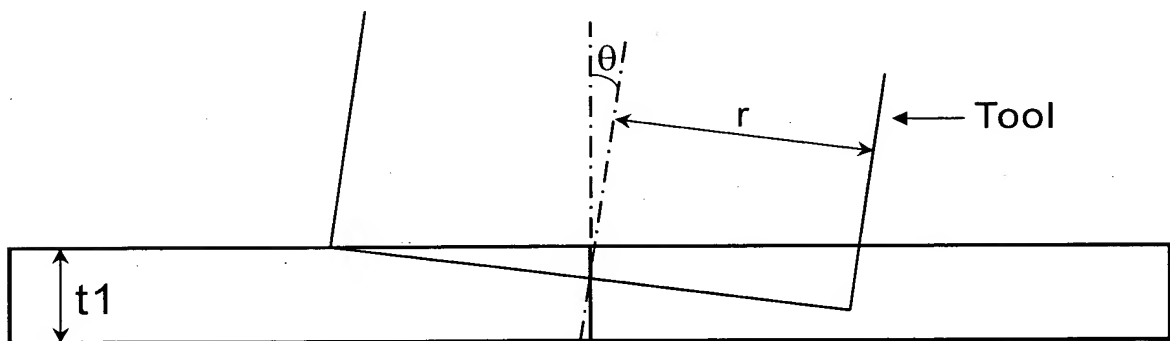
$$(t_1-1)/r < \sin \theta. \quad (2)$$

The Rewritten formula shows that when the two workpieces have

the same thickness, for example, each workpiece is 1.0 mm ( $t_1=1$ ) thick, or more ( $t_1>1$ ), the right side of the Rewritten formula will always have a positive ("+" ) value. This means that the probe of the Tanaka publication will have a certain level of inclination angle for joining two workpieces and thus, the probe will inevitably penetrate into the upper surface of at least one workpiece to the extent of  $2r \cdot \sin\theta$  as shown in Drawing No. 1 below.

Similarly, when the two workpieces are the same thickness, and each workpiece is less than 1.0 mm thick, ( $t_1<1$ ), the Rewritten formula has a negative ("-") value in total. This result also means that the probe of the Tanaka publication will have a certain level of inclination angle for joining two workpieces and thus, the probe will penetrate into the workpieces to the extent of  $2r \cdot \sin\theta$ .

Drawing No. 1



Accordingly, the Tanaka formulas recited in claim 1 of the Tanaka publication confirm that:

- (1) the probe of the Tanaka publication will have a certain inclination angle when joining two workpieces irrespective of the workpieces having the same or different thicknesses;

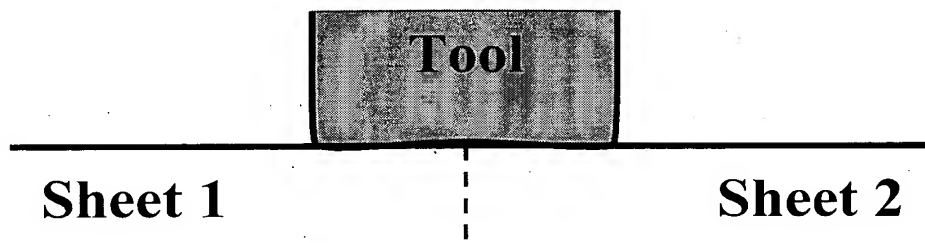
and

- (2) the probe of the Tanaka publication will inevitably penetrate into the workpieces to a certain depth for butt seam welding.

From the above, applicants respectfully submit that 'a deep valley' will be formed on the surface of workpieces because the probe will penetrate into the surface of the workpieces along the butt-welding line. Accordingly, even without a pin beneath the probe, the Tanaka publication cannot avoid forming an unwanted valley along the butt-welding line due to penetration of the probe. This valley will result in adverse effects to the quality of friction butt-welding similar to those shown in Figs. 5 and 7 of the Tanaka publication.

However, in the present invention as recited claim 1, and different from the Tanaka publication, frictional heating takes place on top, that is, "at surfaces" (emphasis added) of the workpieces since the "no-pin" probe will be in a perpendicular position to the workpieces and no inclination angle is permitted by the probe. Indeed, the present invention as recited in claim 1 does not insert the probe into the workpiece at all, see Drawing No. 2 below. As recited in claim 1, by high-speed rotation of the probe, the present invention provides "forcible and intense plastic deformation" 'only at the upper surface of workpieces' that permeates into the workpieces to be joined.

Drawing No. 2



In other words, the present invention as recited in claim 1, provides a new friction stir welding method for butt seam welding two workpieces without inserting the probe into the workpieces, without forming undesirable probe penetration marks (valleys), and without permitting an inclination angle to the probe. Therefore, the present invention advantageously achieves the welding of thin sheets which are difficult to weld with existing friction stir welding, see page 8 in lines 14-16 of the present specification.

Accordingly, for at least these reasons, applicants respectfully submit that claim 1 is not anticipated by, nor obvious over the Tanaka publication, and respectfully request that this rejection be reconsidered and withdrawn.

Claim 4 depends on claim 1, and because a claim which depends on another claim is subject to all the limitations of that other claim, applicants respectfully submit that claim 4 is not anticipated by the Tanaka publication for at least the same reasons discussed above with respect to claim 1.

In view of the remarks above, applicants respectfully request that the rejection of claims 1 and 4 as being anticipated by the Tanaka publication, be reconsidered and withdrawn

Sections 4 and 6 of the Office Action rejected claims 1 and 5 under 35 U.S.C. §102(e) as being anticipated by U.S. Patent No.

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6,585,148 to Aono et al. ("Aono patent"). More specifically, the Office Action stated that the Aono patent teaches all the elements of the friction stir welding process recited in claim 1. Further the Office Action stated that at least Figs. 2 and 6 of the Aono patent show a no pin probe.

Applicants respectfully submit that the Aono patent relates to a process for welding iron-base materials, where the iron-base material is iron-base fine-grained material free from any amorphous phase. According to the Aono patent a high speed-rotating tungsten bar tool is inserted into a weld part and moved along the weld line to conduct friction stir welding. This means that while Figs. 2 and 6 of the Aono patent may not show the probe pin, the Aono patent does have a probe pin being inserted into the weld line as in traditional friction stir welding. As described from column 9, line 67 to column 10, line 27 of the Aono patent:

"Said tungsten tool 4 has a convex tip end, and an M screw is threaded at the small-diameter part (pin) at the remotest part of the tip end. The dimension of the small-diameter shoulder part is 5 mm in diameter and about 3 mm long. Large-diameter part is 10 mm in diameter. The small-diameter part is kept as inserted into the material until the shoulder part comes in contact with the pieces to be welded." (emphasis added)

Thus, despite Figs. 2 and 6, the Aono patent not only fails to teach or suggest a "no-pin probe" as recited in claim 1, but instead as quoted above teaches away from a "no-probe" pin.

Further, nowhere in the Aono patent does one find the wording alleged in the Office Action, that is, "the probe has a diameter more than twice the thickness of the workpieces".

Accordingly, for at least these reasons, applicants respectfully submit that claim 1 is not anticipated by, nor obvious

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over the Aono patent.

Claim 5 depends on claim 1, and because a claim which depends on another claim is subject to all the limitations of that other claim, applicants respectfully submit that claim 5 is not anticipated by the Aono patent for at least the same reasons discussed above with respect to claim 1.

In view of the remarks above, applicants respectfully request that the rejection of claims 1 and 5 as being anticipated by the Aono patent be reconsidered and withdrawn.

In view of the remarks above, and the Replacement Sheet for Figs. 2-4, applicants respectfully submit that the objections and rejections raised in the Office Action have been overcome and earnestly solicit allowance of the application.

If a telephone interview would be of assistance in advancing prosecution of the subject application, applicants' undersigned attorney invites the Examiner to telephone him at the number provided below.


No fee, other than the fee for the one-month extension of time, is deemed necessary in connection with the filing of this Amendment. However, if any fees are required, authorization is hereby given to charge the amount of any such fee to Deposit Account No. 03-3125.

Respectfully submitted,



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I hereby certify that this paper is being deposited this date with the U.S. Postal Service as first class mail addressed to: Commissioner for Patents  
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 21 October 2005  
Richard S. Milner Date  
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